Control of Plant Parasitic Root Diseases and Nematodes In Ornamental Production Systems

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Abstract

Two experiments were carried out in order to determine the efficacy of Slow Sand Filters (SSF) in removing plant pathogens from captured irrigation runoff water.

I. The first experiment determined the optimum flow rate while maintaining a high level of removal. Three flow rates were tested during three seasons. All three treatments attained greater than 99% removal by the end of the 30 day experiments. The medium and fast flow rates plugged after 10 days and could not maintain flows.

II. The second experiment found that Sand Filters established in the presence of Phythophthora capsici for 28 days can remove other Phytophthora species from a different water source.

III. Research is being conducted to characterize the biofilms involved in removing plant pathogens. Identifying the biofilm components may lead to targeted, pathogen-specific treatments utilizing biological agents. As we increase understanding of the biofilm, it can be a reliable tool for commercial plant production.

What is Slow Sand Filtration?

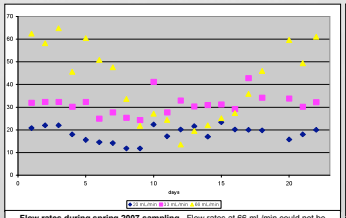
- A biological treatment method, not a physical filter
- Sand serves as a substrate to support microorganism community (biofilm)
- Includes: algae, bacteria, diatoms, zooplankton (Joubert and Pillay, 2008)
- Removes pathogens and many pollutants (Calvo-Bado et al.,2003)
- Slow flow rates: ~150L/hr/m2 of sand surface area
- Low energy input compared to thermal, radiation, or chemical treatment
- Requires simple maintenance: occasional cleaning of the sand surface
- Requirements
- Uniform (UC<3) sand grains of 60 mesh (~0.3mm)
- Sand must remain submerged
- Sand surface must not be disturbed
- Flow control

Introduction

- Nursery runoff can be a resource if captured for reuse.
- Captured runoff may include pathogens from infected plants.
- Slow sand filtration is an old, low technology method.

Project Objectives

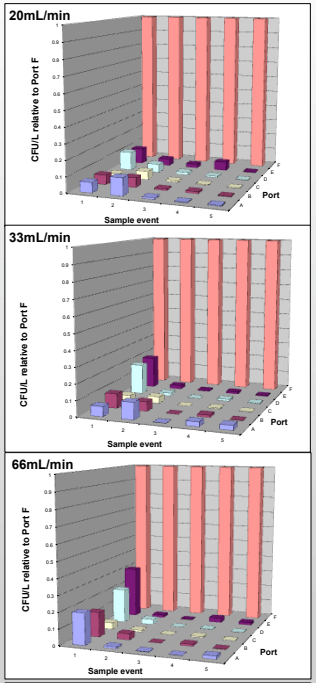
- Determine the maximum rate of filtration while still maintaining effective removal of plant pathogens.
- Determine if a SSF system established against *Phytophthora capsici* can remove *P. ramorum*, a different although related organism.
- Evaluate pairing portable wetlands with SSF.
- Determine the ability of SSF systems to remove nematodes.



Flow rates during spring 2007 sampling. Flow rates at 66 mL/min could not be maintained, but began to recover after day 12.

Portable wetlands system. Environmental Solutions Inc.

Slow sand filtration system. Irrigation run-off from the plants is captured (middle), inoculated with *P. capsici*, and introduced to sand filters (right).



Effective flow rate on treatment efficacy. CFU/L counts relative to untreated sample from port F. Sampling occurred in 5 day intervals.

Materials and Methods

Slow Sand Filtration Optimization

•Three Trials: Spring, Winter, Summer
•Three treatments: 150, 250, and 500 L/m^2·h
•Five replicates per treatment
•Six sample ports per column at 20cm intervals

Trial runs

Columns were constructed with fresh sand, *Phytophthora capsici* introduced into the captured runoff water, and the system was started (day 0). The collection of 500mL samples from each port started on day 1 and repeated every 5 days. The duration of each trial was 30 days with the exception of spring, which was 25. Each column was constructed with 4" pvc pipe divided into two 1m sections. The water head in the top portion forced the water through the sand below. At 20 cm intervals are six sample ports: one above the sand, four within, and one below the sand after the water has exited the column.

Sample Plating

An aliquot from each sample was filtered through a 0.22 µ filter and inverted onto PARP-H media. After 24 hours, the filter was removed and colonies were counted and noted. After another 24 hours, the colonies were tallied and recorded.

Slow Sand Filtration and Other *Phytophthora spp.*

•Two trials in the spring of 2008 & 2009
•Two treatments: 1) Columns established in Davis, CA and transferred to Felton, CA after 30 days and 2) Columns established and run in Felton for duration of the experiment. The inoculum source in Felton was creek water known to contain *P. ramorum* and other *P. sp.*
•Treatment rate: 150L/m^2·h
•Five replicates per treatment

Sample Plating

700mL samples were collected from above and below the sand bed on each column every 7 days. One fresh D'Anjou pear was floated in each sample for 24 hours and then removed to a paper towel lined crisper. Pears were incubated for 48 hours. Samples were taken from lesions and plated onto PARP-H media.

Work In Progress

Portable wetlands

The portable wetlands system (see image) uses a container of gravel substrate engineered to provide optimum horizontal flow and oxygen to the system. *Schoenoplectus spp.* (bulrush) enhances the microbial community whose activity breaks down pollutants in the water.

Portable wetlands with SSF

Treatment performance could be increased by pairing with slow sand filters to the wetlands. The wetlands system would remove sediments and some pollutants, while the slow sand filter eliminates the rest.

SSF biological filter

Slow sand filters contain *Cytophagas spp.*, known to produce cellulose, amylase, and chitinase and *Rhodococcus spp.*, known to produce biosurfactants (Calvo-Bado, et al 2003). DGGE analysis of the microbial communities will be used to identify the organisms responsible for *P. capsici* removal.

Cooperators

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References

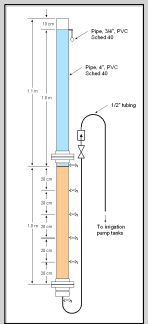
Calvo-Bado, L.A., T.R. Pettitt, N. Parsons, G.M. Petch, and J.A.W. Morgan. 2003. Spatial and Temporal Analysis of the Microbial Community in Slow Sand filters Used for Treating Horticultural Irrigation Water. Applied and Environmental Microbiology. 69: 2119-2125.

Joubert, E.D and B. Pillay. 2008. Visualisation of the microbial colonisation of a slow sand filter using an Environmental Scanning Electron Microscope. Electronic Journal of Biotechnology, 11.

Wohanka, W. Slow Filtration - a Practical Way for Removing Plant Pathogens from Irrigation Water.

Results

- 99% removal was achieved in all trials by 20 days, but early as 15 days after experiment initiation.
- Fastest flow rate (500 L/m^2·h) generally reached complete removal before the medium (250 L/m^2·h) and slowest (150L/m^2·h) rates.
- Only the slow flow rate maintained the desired flow rate for the duration of the experiment.
- The winter trial resulted in virtually no zoospore detection below the sand surface in all three treatments.
- SSF established in the presence of *P. capsici* also removed 99% of other *Phytophthora* species from creek water.
- Filtering creek water caused erratic flow rates and rapid plugging of the SSF.



Slow Sand Filter column design

Conclusions

Optimization Experiment

- Slow Sand Filters remove *P. capsici* zoospores at a very high efficiency after establishment. removal
- Higher flow rates decrease time to reach complete. But higher flow rates also lead to clogging.
- Pre-filtration could increase efficiency of filters and decrease frequency of servicing.
- The system could be scaled for use in a nursery setting.
- 150L/m^2·h treatment performed the best and had the most consistent flow rate

Slow Sand Filtration and Other *Phytophthora spp.*

- SSF removes *Phytophthora* spp. zoospores from stream water.
- High turbidity and organic matter caused early plugging.
- Pretreatment would be necessary for prolonged filter operation.